A Decomposition of Screening and Incentive Effects in Credit Information Systems

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Abstract: In response to problems of over-indebtedness by borrowers in areas where increased competition among microfinance institutions has occurred, there has been an increases in the demand for credit information systems that provide potential lenders both positive and negative data about borrowers. We then develop a model that illustrates how credit information systems mitigate both adverse selection and moral hazard problems in credit markets through "screening" and "incentive" effects. The model is then used to make predictions about the effect of a credit information system on default rates.

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Introduction

As the number of credit providers in developing countries has grown enormously in recent years, governments have begun to implement credit information systems at a breathtaking pace. Papers such as Vercammen (1995), Padilla and Pagano (2000) and Jappelli and Pagano (2000) have begun to lay a foundation for analyzing the nature of information sharing between lenders. In this paper we decompose the effect of a credit information system, or credit bureau, into two distinct effects: a screening effect, and an incentive effect. We subsequently propose some hypotheses regarding the effect of credit information systems on default rates and portfolio composition.

The Model

To more clearly conceptualize the effects of information sharing in credit markets, we work within a simplified version of the model presented in McIntosh and Wydick (2004). Here we consider a borrowing pool characterized by a set of borrowers, indexed in order of a uniformly distributed level of initial productive assets $k_i \in \boldsymbol{K}$. This initial asset of borrower *i*, which could represent existing physical capital, human capital, or a combination of these, is assumed to be observable to all potential lenders.

Borrowers can receive loans either from an informal sector source such as a moneylender, or from a formal (or more formal) lender such as a microfinance institution. Let the size of a borrower's loan be equal to V_i and let r_i equal the interest rate for a formal sector loan. If a borrower with assets k_i receives a microfinance loan of V_i at interest rate r_i, the loan yields a low return of $\underline{\hat{a}}V_i$, with probability $p_i(k_i, V_i)$ where $\underline{\beta} < 1$, and a high return of $\bar{\hat{a}}V_i > V_i(1+r_i)$ with probability $1 - p_i(k_i, V_i)$. The probability of the low return, in which the borrower is forced to default on 1 - $\underline{\beta}$ of the loan, is decreasing in k_i ($p_k < 0$) and increasing in V_i ($p_v > 0$) with $p_{kv} < 0, p_{vv} > 0$, and $p_{kk} < 0$. In the event of default, the formal sector lender is able to capture the entire amount $\underline{\beta} V_i$ from the borrower. As a benchmark we assume that informal sector financing yields a zero-profit return to a borrower, *i.e.* that the interest rate from a moneylender (or the implicit interest rate from self-finance) is equal to some $\bar{r} \equiv \bar{\beta} - 1$. The interest cost of capital for formal financing is equal to *c* and on each loan it incurs a basic level of fixed administrative costs, *F*. This makes the profit for the lender from any borrower *i* equal to

$$\Pi_i^L = (1 - p_i)(1 + r_i)V_i + p_i \underline{\beta} V_i - (1 + c)V_i - F \,. \tag{1}$$

The shape of the lender's iso-profit curves in $\{V_i, r_i\}$ space, we totally differentiate (1) with respect to V_i and r_i to obtain:

$$\frac{dV_i}{dr_i} = \frac{V_i(1 - p)}{(p_v V_i + p)(1 + r_i - \underline{\beta}) - (r_i - c)} \,. \tag{2}$$

Under formal sector borrowing, if a borrower's project fails, the borrower realizes a zero return on the project by forfeiting $\underline{\beta} V_i$ to the lender along with future benefits, _, of accessing credit at the preferred interest rate $r_i < \bar{r}$ for any loan size V_i.

Along with being characterized by an initial level of productive assets, each borrower *i* is also characterized by a personal rate of time preference $\rho \in \lfloor \underline{\rho}, \bar{\rho} \rfloor$ per lending period by which these future benefits are discounted. We assume that borrowers who default are denied all future credit, and so discounted profit for borrower *i* is given by

$$\Pi_i^B = (1 - p)\left[(\bar{\beta} - 1 - r_i)V_i + \frac{\Gamma_i}{\rho_i} \right] \tag{3}$$

By totally differentiating borrower *i*'s profit function with respect to V_i and r_i, we also obtain the slope of the set of borrower *i*'s iso-profit curves in $\{V_i, r_i\}$space:

$$\frac{dV_i}{dr_i} = \frac{V_i(1-p)}{(1-p-p_v V_i)(\overline{\beta}-(1+r_i)) - p_v \dfrac{\Gamma_i}{\rho_i}} \tag{4}$$

Note that the lender's iso-profit curves are negatively (positively) sloped for values of $V_i < (>) \frac{1}{p_v}\left[\frac{(r_i - c)}{(1+r_i-\underline{\beta})} - p\right]$. The borrower's iso-profit curves, conversely, are positively sloped for $V_i < (1-p)/p_v$ when $(1-p-p_v V_i)(\overline{\beta}-(1+r_i)) > p_v \frac{\Gamma_i}{\rho_i}$, and negative otherwise. These relationships imply that the value of V_i at which the borrower's iso-profit curve bends backward is higher than that for the lender provided that $1+c > \underline{\beta}$, or that the lender loses money in the bad state. Assume that Bertrand competition exists between borrowers which reduces $\Pi_i^L = 0$ on the equilibrium loan to any borrower *i*. Equilibrium will occur at the tangency point between the borrower *i*'s iso-profit curve and the lender's iso-profit curve where $\Pi_i^L = 0$, depending on a borrower's rate of time preference as seen in Figure 1:

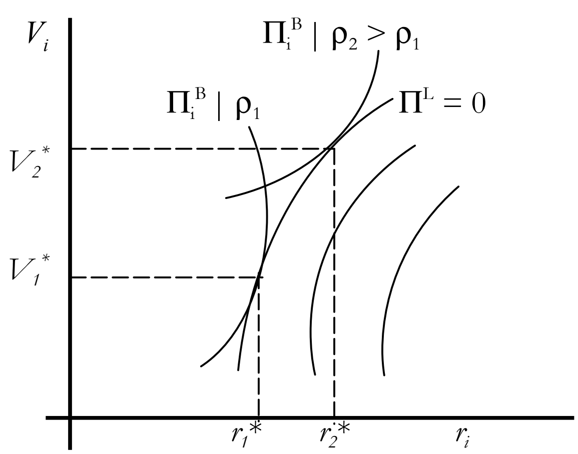

Figure 1

(a) Decomposition of Incentive and Screening Effects.

Implementation of a credit bureau yields two distinct and positive effects, which we decompose and describe in this section. To this end, consider some borrower *i* with initial productive assets k_i that are observable to potential lenders but with $\rho_i \in [\underline{\rho}, \overline{\rho}]$ unobservable to lenders. Because borrowers with a lower rate of time preference place a greater weight on future credit access at favorable interest rates, and because $p_v > 0$, patient borrowers will demand smaller loans in equilibrium. In contrast, less-patient borrowers with a higher rate of time preference will demand larger loans. Lenders are happy to supply these larger loans, which are accompanied by a greater level of risk, by offering them in equilibrium at a higher interest rate, as seen in Figure 1 with a borrower characterized by $\rho_2 > \rho_1$. Consequently, for a certain subset of borrowers with initial assets k_i, a borrower's loan demand is *de facto* revealing of his rate of time preference.

Now consider impatient borrowers with "very high" rates of time preference. Such borrowers place minimal weight on the risks associated with loans that are large relative to a borrowers assets, and their ramifications for future credit access. Specifically, consider a borrower with initial assets k_i, but with ρ_i sufficiently high that his expected (discounted) profit from his equilibrium contract on a single loan is less than or equal to his profit from obtaining multiple smaller loans. This may hold since the interest rate charged on each of the smaller loans would be lower than what would be charged for the single larger loan.

To see this more specifically, let the coefficient _ represent the probability that a given lender is able to identify the existence of an outstanding loan by borrower *i* with another lender. Borrowers caught taking multiple loans are punished through denial of access to credit at the preferential interest rate. Since *ex ante* the rate of time preference is hidden information from a lender, a borrower will prefer to obtain two separate loans[i] of size $\widetilde{V}_i$ than the single loan of size $\breve{V}_i$ if

$$\Pi_i^B = \left(1 - p\left(\breve{V}_i\right)\right)\left[\left(\beta - 1 - \breve{r}_i\right)\breve{V}_i + \frac{\Gamma_i}{\rho_i}\right] < \left(1 - \alpha\right)\left(1 - p\left(2\widetilde{V}_i\right)\right)\left[\left(\beta - 1 - \widetilde{r}_i\right)2\widetilde{V}_i + \frac{\Gamma_i}{\rho_i}\right]. \qquad (5)$$

The effect of the credit bureau can be analytically decomposed into the *screening* effect and an *incentive* effect, both of which lead to decreases in the expected default rate. Defining $\gamma = \gamma(\alpha)$ as the probability of multiple loan-taking for any borrower *i*, and letting $\breve{p}_i(\breve{V}_i, k_i)$ and $\widetilde{p}_i(\widetilde{V}_i, k_i)$ equal expected probabilities of default for borrowers (at a given level of k_i) with single and multiple loans respectively, we obtain

$$\overline{p}_i \equiv \frac{(1-\gamma)\breve{p}_i + \gamma(1-\alpha)\widetilde{p}_i}{1-\gamma\alpha} \qquad (6)$$

Letting $\rho^*(\alpha)$ be the rate of time preference for which (5) is satisfied with equality, an increase in α decreases the likelihood of multiple loan-taking, thus, $\frac{d\rho^*}{d\alpha} > 0$ and $\gamma_\alpha < 0$.

The *screening* effect of the credit bureau is the direct change in lender profits resulting from the ability, over increasing levels of α, to screen (previously indebted) impatient borrowers with $\rho \in [\rho^*, \overline{\rho}]$ from the portfolio. The *incentive* effect can be seen in the borrower's switching condition given in (5): fewer impatient borrowers will risk taking multiple loans as their chances of being detected increase. Different levels of α change the behavior of some borrowers in the neighborhood of ρ^*, a higher α inducing some borrowers to take single loans, and lower α inducing some to take multiple loans.

As information sharing between lenders increases via a credit bureau, we can think of the screening effect and incentive effect as two distinct and positive effects of the existence of information sharing. The total effect of information on default is obtained by partial differentiation of the expected default rate in (6) with respect to α, yielding

$$\overline{p}_\alpha \equiv \frac{\partial \hat{p}}{\partial \alpha} = [\gamma(1-\gamma) - \gamma_\alpha(1-\alpha)]\frac{(\breve{p} - \tilde{p})}{(1-\gamma\alpha)^2} \tag{7}$$

Since γ_α represents the change in borrower behavior as a result of the probability of being detected, we can isolate the screening effect by setting $\gamma_\alpha = 0$, to obtain

$$\frac{\partial \overline{p}_i}{\partial \alpha}\Big|_{\gamma_\alpha = 0} = \frac{\gamma(1-\gamma)(\breve{p}_i - \tilde{p}_i)}{(1-\gamma\alpha)^2} < 0. \tag{8a}$$

Subtracting the screening effect in (8a) from total effect in (7) we can isolate the incentive effect in (8b):

$$\frac{\partial \overline{p}_i}{\partial \alpha} = [-\gamma_\alpha(1-\alpha)]\frac{(\breve{p}_i - \tilde{p}_i)}{(1-\gamma\alpha)^2} < 0. \tag{8b}$$

Notice in (8b) that as γ_α (borrower sensitivity to information sharing) increases, the more default rates decline in response to increased lender information sharing. The screening effect, in contrast, embodies a direct effect of information on the default rate; the effect presupposes no awareness of α on the part of borrowers. Thus the screening effect likely captures the more immediate impact of a change in α. The incentive effect, in contrast, may constitute a longer-term effect that magnifies the response of default to changes in α if it takes time for borrowers to become aware of the new information-sharing environment among competing lenders.

The incentive effect can be illustrated most clearly in the following way. First, we compute the critical switching value of $\rho_i{*}(\alpha)$ for borrowers at any given level of assets k_i from (5) to be

$$\rho{*}(\alpha) = \frac{\left(\alpha + (1-\alpha)p(2\tilde{V}) - p(\breve{V}_i)\right)\Gamma}{(1-\alpha)(1-p(2\tilde{V}))(\beta - 1 - \tilde{r})2\tilde{V} - (1-p(\breve{V}_i))(\beta - 1 - \breve{r}_i)\breve{V}} \tag{9}$$

Notice that in the baseline case where _ = 0 any borrower with ρ_i less than $\hat{\rho}$ only takes a single loan from a single lender though there is no credit information sharing, where $\hat{\rho} \equiv \rho^*(0) = \frac{\left(p(2\breve{V}) - p(\breve{V}_i)\right)\Gamma}{\left(1 - p(2\breve{V})\right)\left(\beta - 1 - \tilde{r}\right)2\breve{V} - \left(1 - p(\breve{V}_i)\right)\left(\beta - 1 - \tilde{r}_i\right)\breve{V}}$. Also notice that when α is above a critical level of $\hat{\alpha}$, where $\hat{\alpha} = 1 - \frac{\left(1 - p(\breve{V}_i)\right)\left[\left(\beta - 1 - \tilde{r}_i\right)\breve{V}_i + \frac{\Gamma_i}{\overline{\rho}}\right]}{\left(1 - p(2\tilde{V}_i)\right)\left[\left(\beta - 1 - \tilde{r}_i\right)2\tilde{V}_i + \frac{\Gamma_i}{\overline{\rho}}\right]}$ it never pays for even the most impatient borrower with $\overline{\rho}$ to try to game the system by taking loans from multiple sources. Therefore, with any level of information sharing α less than $\hat{\alpha}$, the level of information sharing in the credit bureau determines the fraction of borrowers with $\hat{\rho} < \rho_i \leq \overline{\rho}$ taking multiple loans, as seen in Figure 2:

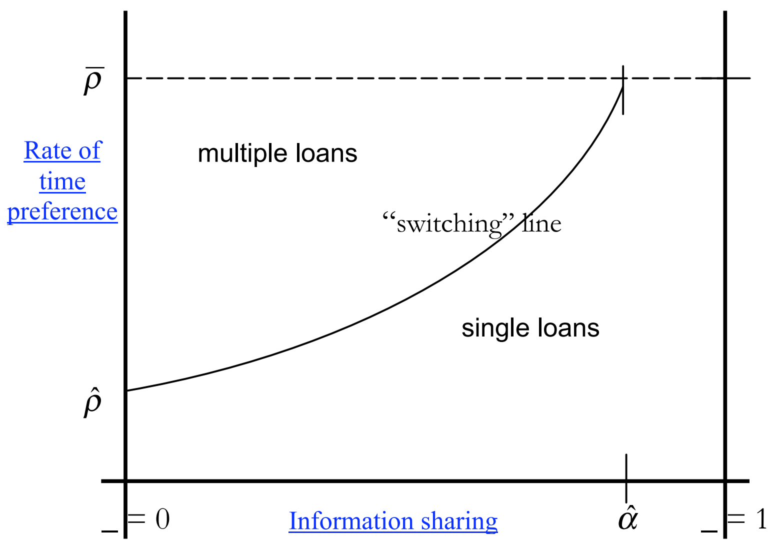

Figure 2

In Figure 2, any borrower operating in a credit environment with information sharing equal to _ that has a rate of time preference lying above the switching line will borrow from multiple lenders; a combination of _ and ρ that lies below the switching line will result in a single loan from a single lender.

(b) Effect of Credit Bureau on Equilibrium Loan Contract for Borrowers. As seen in (7), information sharing reduces the expected default rate for any borrower with initial assets k_i. We make use of the profit equation for the lender given in (1) to obtain the expression for expected lender profits:

$$\Pi_i^L = (1-\overline{p})(r_i - c)V_i - \overline{p}V_i(1 + c - \underline{\beta}) - F \qquad (10)$$

where $\overline{p} \equiv (1-\gamma)\breve{p} + \gamma\tilde{p}$. Holding lender profits and V_i constant, we can totally differentiate (10) with respect to α and r_i to obtain $\frac{dr_i}{d\alpha} = \frac{\overline{p}_\alpha (1 + r_i - \underline{\beta})}{(1-\overline{p})} < 0$. For $\alpha < \hat{\alpha}$, the increase in α from lender information sharing shifts the zero iso-profit curve of the lender to the left, implying that the interest rate for any given loan size V_i falls, resulting in a Bertrand equilibrium contract that yields a higher profit for every formal sector borrower *i* as seen in Figure 3, where $\Pi^B(V_2,r_2) > \Pi^B(V_1,r_1)$:

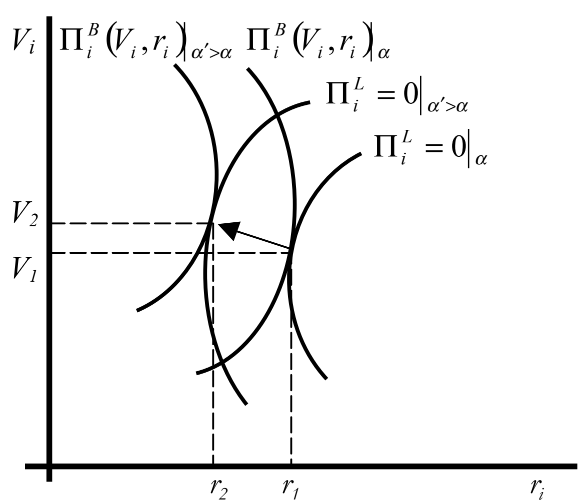

Figure 3

(c) Effect of Credit Bureaus on Graduation Rates of Borrowers from Informal to Formal Financial Sector.

Due to fixed costs of lending, *F*, and the fact that borrowers can only be induced into formal financing at some formal interest rate lower than $\bar{r}$, there exists a subset of borrowers with low levels of initial assets for whom positive profits are infeasible for the formal lender. By setting (3) equal to (4) and totally differentiating it is straightforward to show that the profit-maximizing equilibrium loan is increasing in k_i, or that $\frac{dV_i^*}{dk_i} > 0$. Thus, initially wealthier borrowers receive larger loans. Note that a formal sector lending contract must satisfy the lender feasibility condition that . Thus we define the smallest level of initial assets of the borrower for which this feasibility condition holds (at some information-sharing level α) as the initial assets of borrower *i* with $\hat{k} \in \boldsymbol{K}$.

Now suppose that though the implementation of a credit bureau or similar institution, the level of information sharing α increases. An increase in information sharing allows the lender to reach a marginally poorer borrower with initial level of assets than $\hat{k}$. This can be seen by substitution of $\hat{k}$ into (10), and noting that due to fixed costs, lender profits equal zero for this poorest borrower in the portfolio. Total differentiation of (10) with respect to _ and $\hat{k}$ reveals that $\frac{d\hat{k}}{d\alpha} = -\frac{\bar{p}_\alpha}{\bar{p}_k} < 0$, or as α increases, the marginal borrower who receives a loan becomes less wealthy as information sharing increases. The result that greater levels of information sharing lead to credit access by less-wealthy borrowers stems from efficiency gains in the financial system via lower default rates. Lower default rates reduce the cost of lending so that smaller loans to borrowers with fewer assets become profitable. The implication is that the implementation of a credit bureau is likely to result in upward mobility from informal finance to formal lenders for many marginally poor borrowers who were previously denied formal financial sector credit.

Conclusion and Further Research

The result that credit information systems can both lower default rates and lead to greater inclusiveness of low-income borrowers within a microfinance network has important policy implications for development practitioners. These hypotheses, however, must be subject to empirical tests. Our future research involves the collection of data from a Guatemalan field experiment that seeks to empirically decompose the screening and incentive effects of a credit information system.

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[i] The size of each of the two separate loans is likely to be larger than the size of the single loan, since the reduction in the interest rate from a smaller loan size induces a greater individual loan size for each of the two loans (see McIntosh and Wydick, 2004).